An Overview of NASA Glenn Research Center's Aeronautical Communications Technology Development Efforts

2nd Integrated CNS Technologies Conference

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Overview of Current Projects

Airspace Systems Program

Advanced Air Transportation Technologies (AATT):

Advanced Communications for Air Traffic Management (AC/ATM)

- Satellite Communications for ATM
- CNS for Distributed Air-Ground Traffic Management

Virtual Airspace Modeling and Simulation (VAMS)

VAMS- CNS

- Communications, Navigation and Surveillance System Modeling

Small Aircraft Transportation System (SATS):

- Airborne Internet

Aviation Safety Program

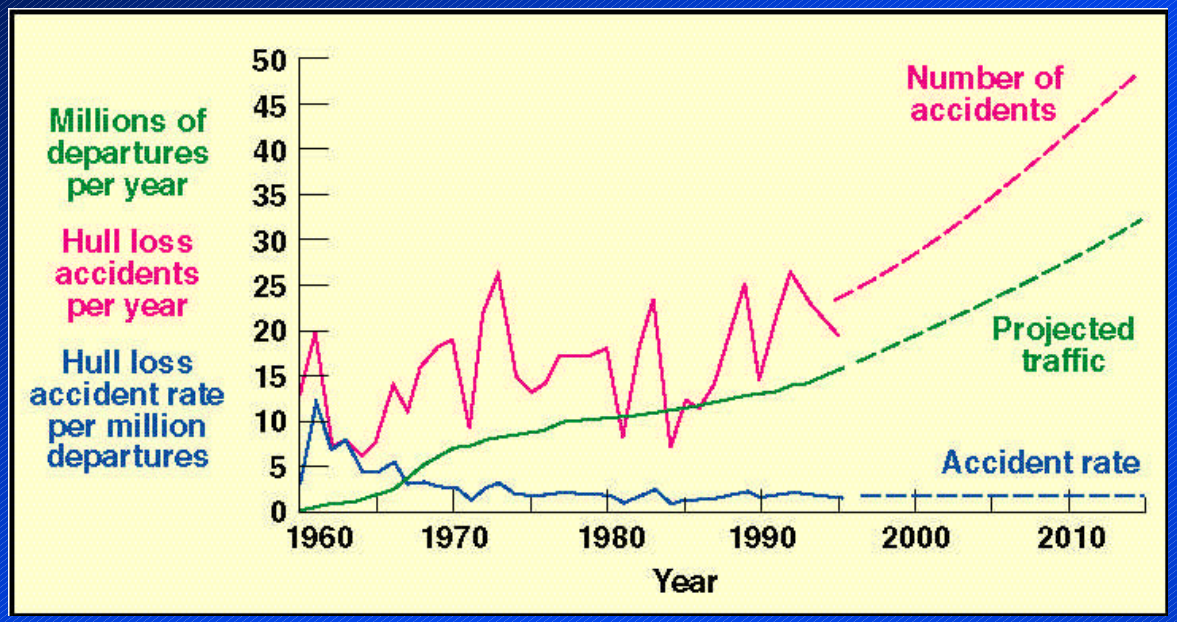
Weather Accident Prevention (WxAP):

Weather Information Communications (WINCOMM)

- Air Transport to General Aviation
- National and Worldwide Datalink Communications

The Aviation Capacity and Safety Challenge

Air Traffic to Triple in Next 20 Years



NASA Technology Goals

- **Reduce the aircraft accident rate by a factor of five within 10 years, and by a factor of ten within 25 years**
- **While maintaining safety, increase aviation throughput in the terminal area by 40%, and en-route by 20%.**

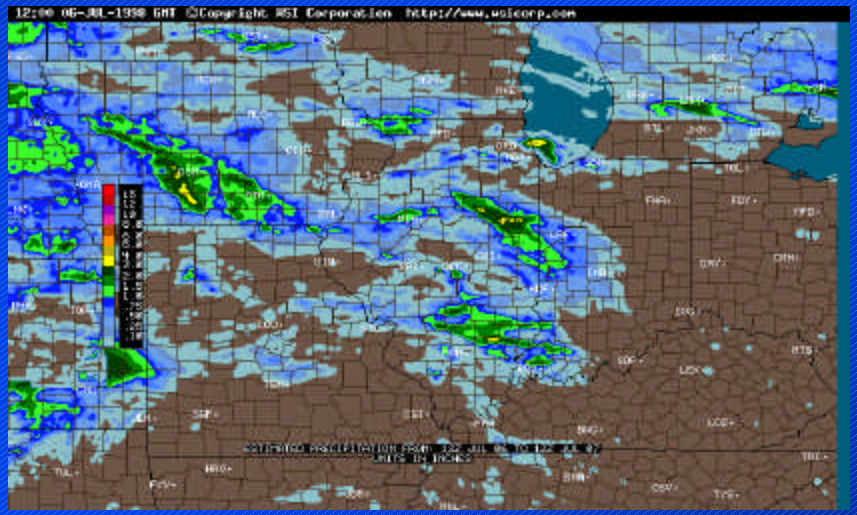
"The current air traffic management system is near its capacity limits with extensive system delays and inefficiencies resulting in annual losses to users estimated at over $4 B."

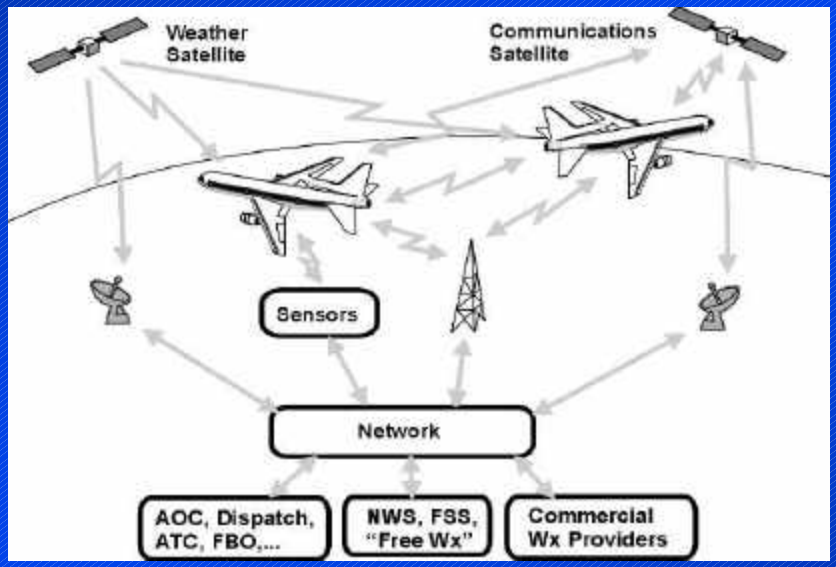
AvSP: Weather Information Communications

Objective:

The WINCOMM project:

Advanced communications and information technologies to enable high quality, timely dissemination of aviation weather information to all relevant global aviation users.





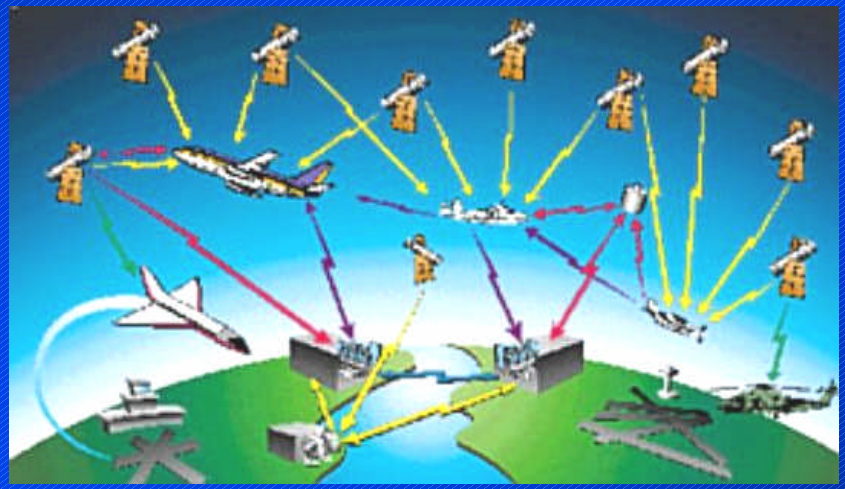
Goals:

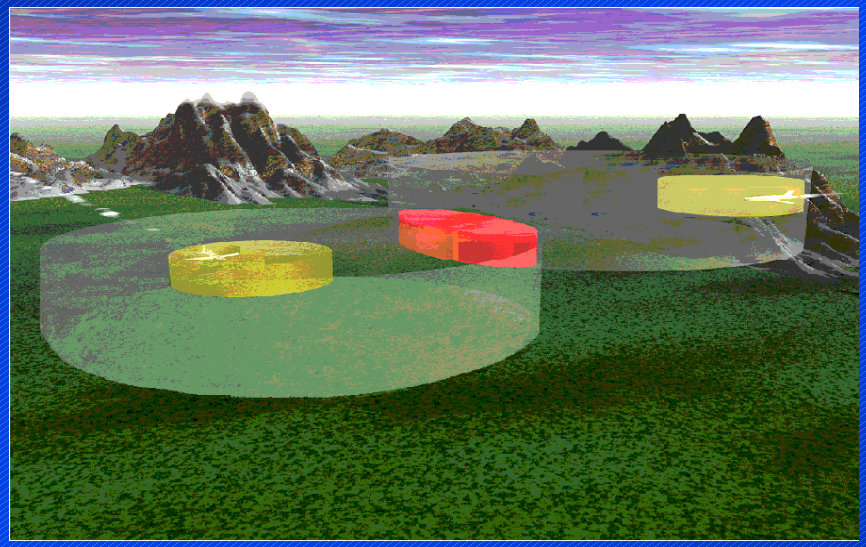
- Enable high quality/graphical, timely weather information to all users promoting safety and efficiency.
- Provide greater access/connectivity across all users/platforms on the information network, both airborne and ground-based, nationally as well as worldwide.
- Promote an integrated global information network enabling collaborative decision-making further enhancing aviation safety.

AATT: Advanced Comm for ATM

Project Goal:

The AC/ATM project is developing and adapting advanced communications technology to enable advanced air traffic management methods and provide global connectivity to all aircraft via satellite communications in a global aviation information network.



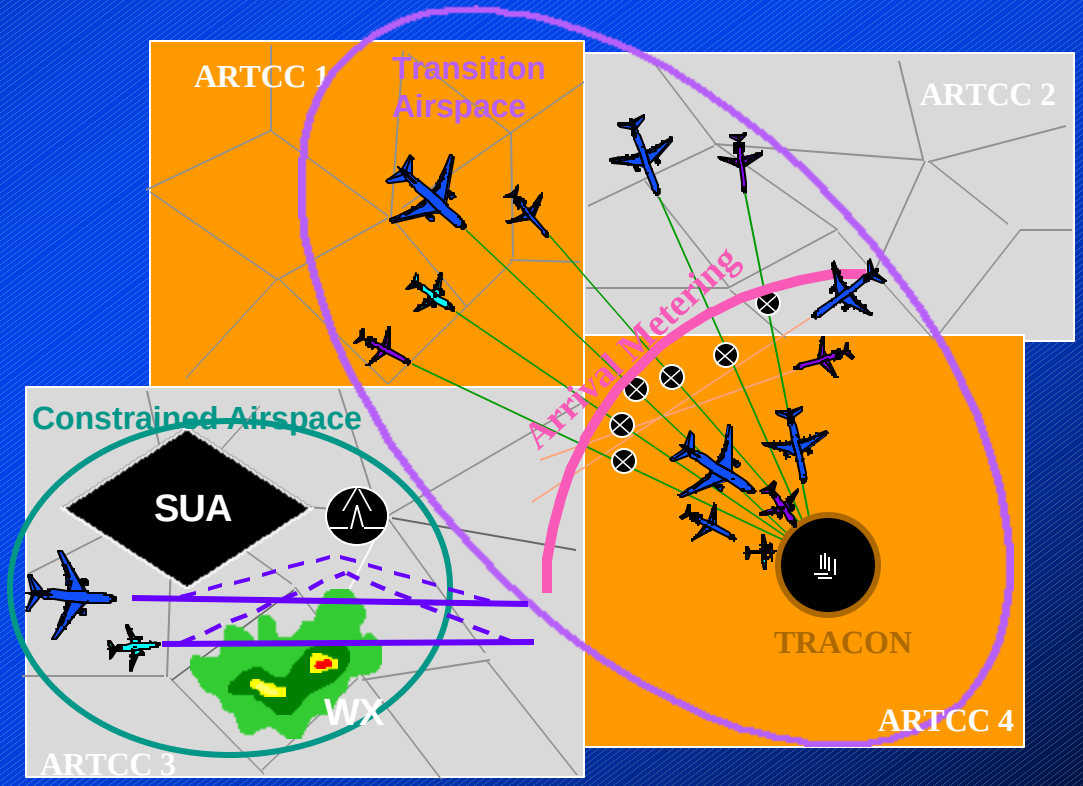


Specific Project Objectives:

- **Determine communications systems requirements for the emerging AATT ATM concept(s).**
- **Identify communication system and network approaches to meeting future requirements.**
- **Support the demonstration of AATT ATM concepts and hardware.**
- **Develop select high-risk, high payoff advanced communications technologies.**

DAG TM Feasibility Challenges

- Distributed responsibility for separation assurance
- Distributed responsibility for traffic management
- Dynamic airspace constraints
- Flow-constrained operations
- Mixed-equipage traffic
- Inter-sector/center coordination
- Human-automation interaction
- Human performance
- CNS infrastructure design
- Decision support technology design
- Communications technology design
- User competition
- Airspace access



SATS: Airborne Internet

Small Aircraft Transportation System

SATS develops and integrates emerging vehicle and infrastructure technologies, and, enables access to the vastly under-utilized infrastructure of smaller non-hub airports and airspace. More efficient access to congested hubs will create unimagined transportation speed for more people to reach more destinations.

Airborne Internet

- Provide a comm architecture that delivers aviation information services in an Internet-like manner where aircraft and ground facilities will be interconnected nodes on a high-speed digital comm network.

- 2022 AI Fundamental Characteristics:
  - Client server analogy
  - Aviation Information System
  - Integrated CNS - Worldwide compatibility
  - Seamless connectivity
  - High user and system capacity

NASA Aeronautical Communications R&D

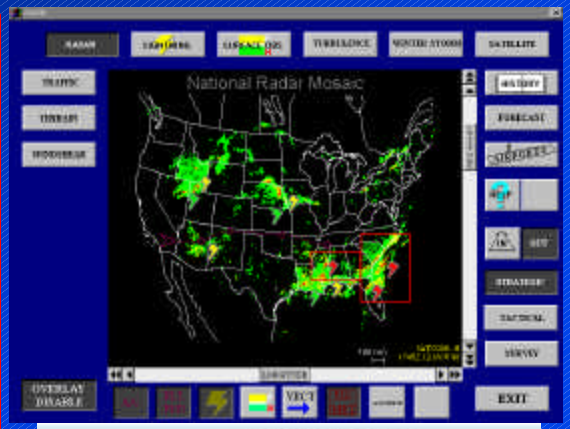
- Aeronautical Communications Requirements, System Architectures, Networks and Protocol Research
- Simulation and Modeling
- Datalink Development/Demonstration Cooperative Research
- Communications Technology Development for Aeronautical Applications
- Broadband Aeronautical SatCom Terminal Development/Demonstration

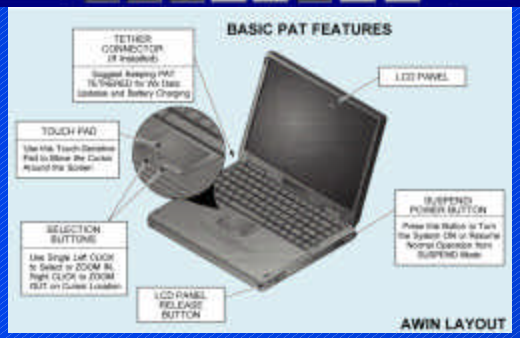
Air Transport: Ground-based Datalinks

FedEx MD-11

USAF C-135C

Boeing Transport Cooperative Agreement

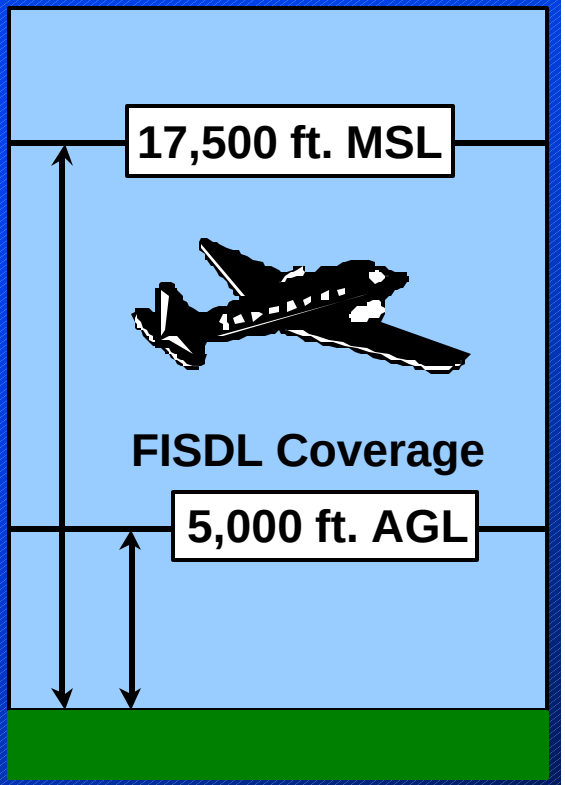




Honeywell Transport Cooperative Agreement

- **Phase I (FY98-00) efforts (Boeing & Honeywell) utilized off-the-shelf comm for rapid implementation (air phone, VHF/ACARS, …)**
- **Optimal long-term operational end-solution may differ (VDL-2, SATCOM)**
- **Recent In-Service-Evaluations (ISE) of HI system by UAL (Electronic Flight Bag concept)**

General Aviation: Ground-based Datalinks



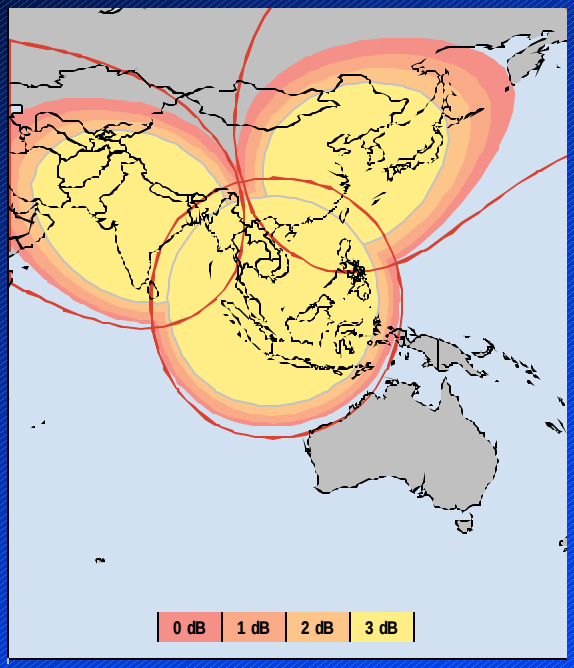
Left: ARNAV VHF Datalink in Cessna 180

Center: Yoke-mounted and Tethered Honeywell Display

Right: Flight Information Services Coverage

- **Cooperative research efforts with ARNAV Systems and Honeywell developing VHF-based broadcast and 2-way datalink cockpit weather systems for General Aviation**
- **Same companies selected by FAA for Flight Information Services Datalink (FISDL) service**

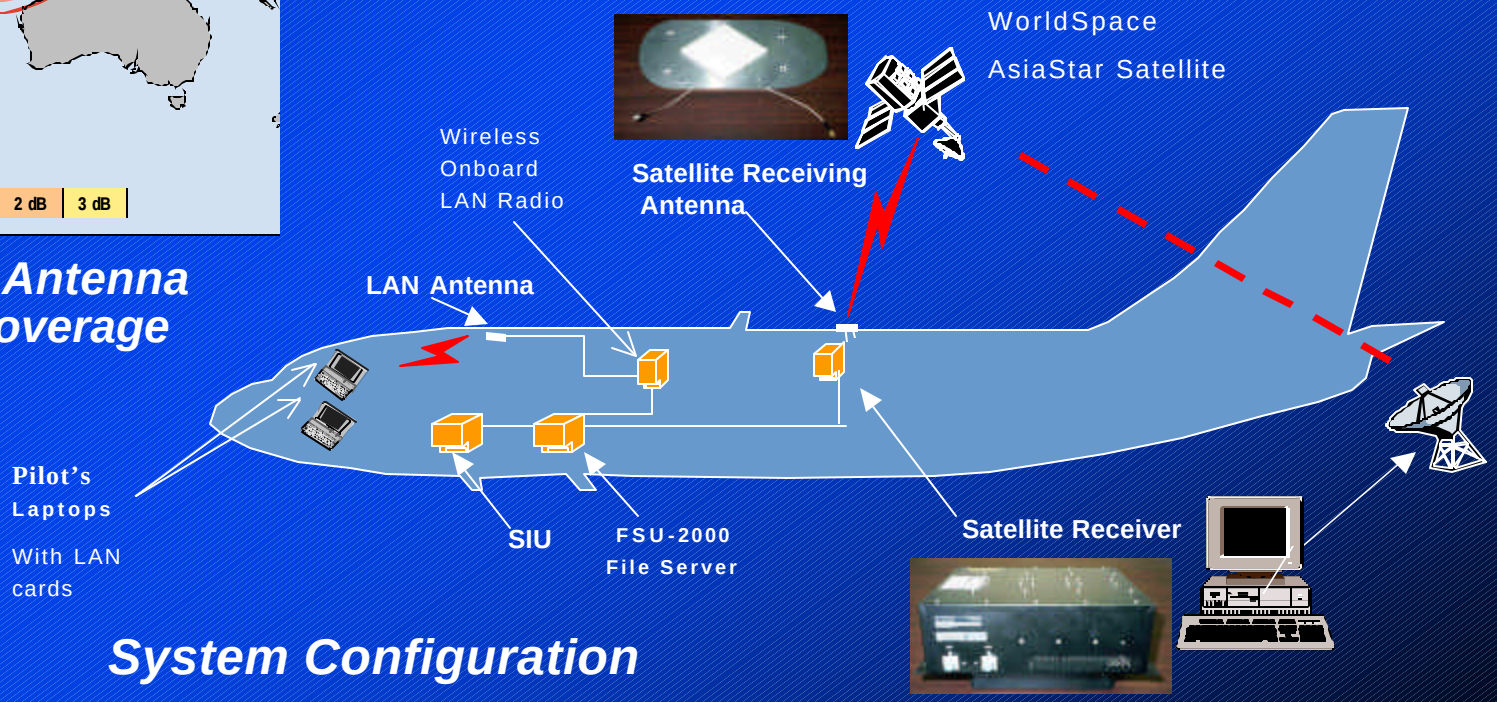
Air Transport: Satellite-based Datalinks



AsiaStar Antenna Beam Coverage

Worldwide Transport

Technology development and operational evaluation of graphical weather to the cockpit via broadcast SATCOM broadcast, Satellite Digital Audio Radio Services (S-DARS), for commercial transport oceanic operations.



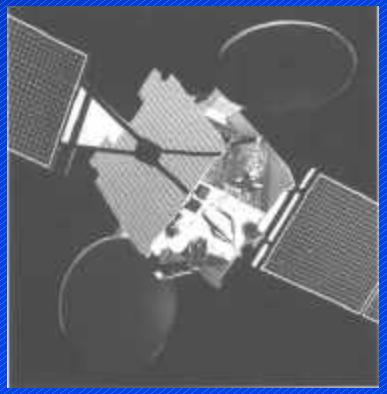
System Configuration

General Aviation: Satellite-based Datalinks

Flight test and evaluation of worldwide weather datalink capability using broadcast Satellite Digital Audio Radio Services (S-DARS)

Johannesburg, South Africa

September, 1999



AfriStar Satellite

Patch Antenna Mounted to Cessna 172

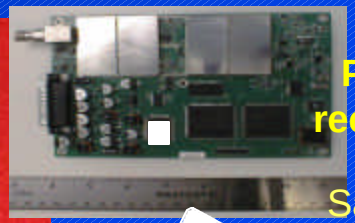
Internal Equipment (GPS, Laptop Computer, etc.)

Satellite Receiver

General Aviation: Satellite-based Datalinks

Commercialization of a satellite broadcast system for near-real time weather information for pilots

PWA™ antenna



PWA receiver

Satellite providing CONUS coverage

GL to 40,000+ ft

PWA™ weather data

PWA™ airborne weather display

Based on US Patent #5265024 Nov. 23, 1993

- Digital data link uses advanced turbocoding techniques
- Composite mosaic NEXRAD radar image (~ 1 nm resolution), graphical METARs, TAFs and Aviation Weather Warnings and textual METARs and TAFs.
- All products are from a certified aviation weather information provider and conform to RTCA SC-195 Flight Information Services-Broadcast (FIS-B) MASPS (DO-267).

Monitoring network

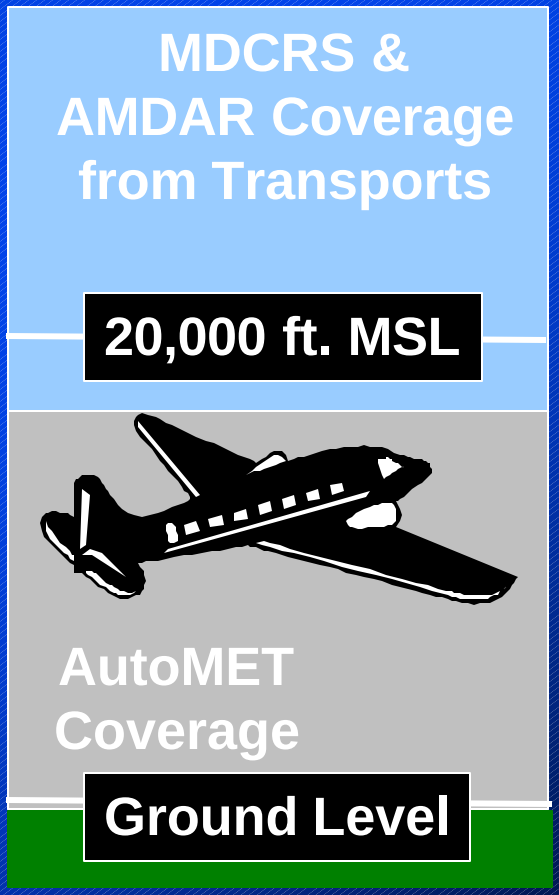
Ground station

ViGYAN ground processor

Weather data

Low-Altitude AutoMET Reporting

- Use regional, GA aircraft operating below 20,000 ft altitude to sense and report lower atmospheric data
  - Moisture,Temperature, Winds, Turbulence, Icing
- To be used by:
  - Forecast models, Weather Briefers, Controllers, Other aircraft
- In January 2002, Tropospheric Airborne Meteorological Data Reporting (TAMDAR) sensor built by ODS was mounted on the GRC Twin Otter aircraft.
  - This sensor was flown on 7 flights, collecting data for subsequent transmission off the aircraft.
- Two separate datalink systems were flown in these initial concept flights.
  - EchoFlight system, which utilizes medium-earth orbit (MEO) satellites for transmission of data.
  - Universal Access Transceiver (UAT), an air-to-air and air-to-ground link, primarily used for ADS-B/surveillance messages.



Initial Datalink Concept Flights

Low Altitude Weather Data Reporting

Flight Equipment Racks

Flight Tracks, 1/25/02

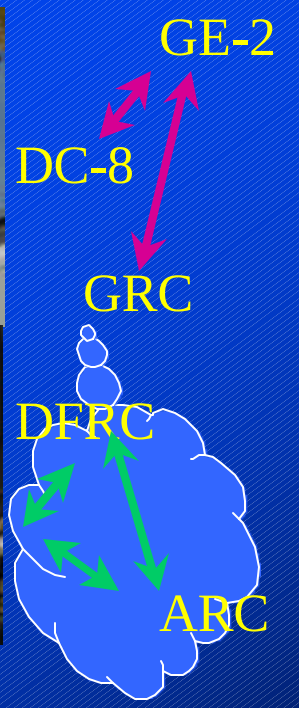
TAMDAR Sensor

Twin Otter

Air Transport: Satellite-based Datalinks

NASA Glenn development and demonstration program for key aeronautical satellite communications technologies:

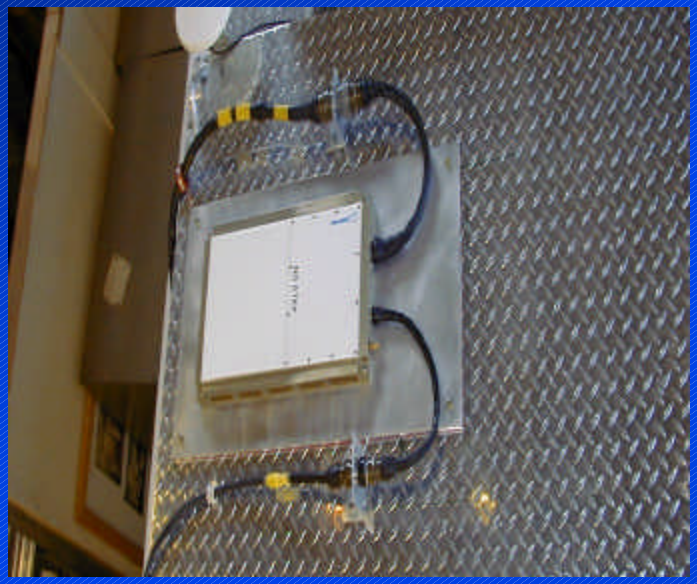
- Phased array antennas
  - Ku Band development complete
  - Ka Band development on-going
- Antenna pointing/tracking algorithm research on-going
- Optimal modulation/coding for aero-satcom link - research on-going
- Fiber-optic multi-signal distribution, testbed prototype under development
- Broadband mobile terminal has been developed and tested
  - Ground mobile testbed
  - Flight demonstrations



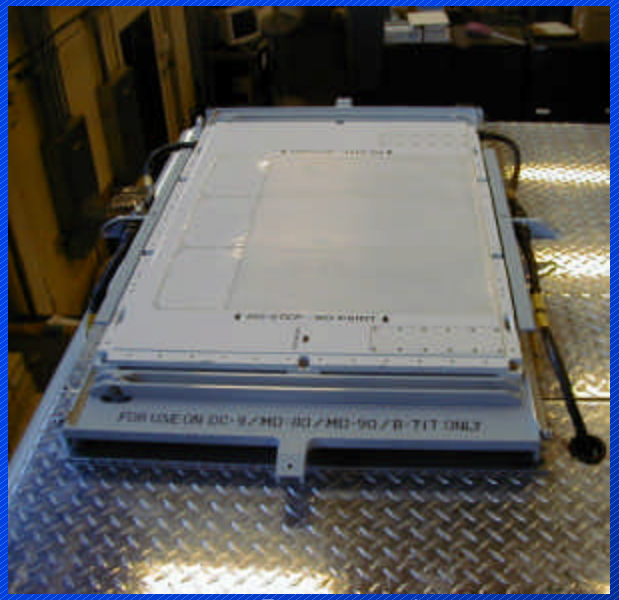
Enabling Antenna Technology

Ku-Band Tx Phased Array Development

- Boeing developed antenna via GRC cost-share.
- Broadband (active antenna); 256 kbps transmit.
- Low profile; low drag, fuel savings, lower cost.



Ku-Band Transmit Phased Array Antenna



Ku-Band Receive Phased Array Antenna

- Electronic steering; no moving mechanical parts, higher reliability, lower MRO costs.
- Multiple, independent-beam capability; one antenna, multiple satellites.

Broadband Aeronautical SatCom Terminal Development/Demonstration

NASA Glenn has developed a mobile aeronautical satellite communications terminal, designed for both ground mobile and air-mobile experiments and demonstrations:

- Evaluation/demonstration of communications technologies.
- Demonstration of broadband aeronautical communications.
- Demonstration of ATM and Weather dissemination via satellite.
- Development/evaluation/demonstration of aeronautical satellite communications networks and protocols.

- Mobile terminal development, test and integration is complete, ground mobile experiments occur between flight tests.
- First flight tests, using NASA Dryden DC-8, completed in December 2000. *(Described previously in Session C1)*
- Second flight tests, using NASA Langley 757, going on now (April – May, 2002).
- *Additional Flight Tests in 2003 and 2004 will demonstrate advanced applications and protocols, such as ADS, FIS, TIS, CPDLC, ATN, IPv6, UMTS, etc.*

Broadband Terminal

Ku Band Mobile Aero-SatCom Terminal

The Ku Band Aero terminal is based on the Boeing transmit/receive antennas. It is currently housed in a specially equipped van for ground mobile experiments.

Ground mobile experiments will test antenna performance and pointing/tracking algorithms, communications equipment performance, and performance of aeronautical communications networks and applications in a mobile environment.

The mobile terminal is also designed for flight experiments to test these parameters under real flight conditions.

Boeing Ku-band receive antenna

Boeing Ku-band transmit antenna

Interior Communications and Control Equipment

Broadband Terminal – Flight Tests

Flight Tests of the Ku-Band Mobile Aero-Satcom Terminal on the NASA DC-8 – Dec, 2000

- Demonstrated first ever in-flight network and communications technologies.
- Achieved 256 kbps transmit, 2.180 Mbps receive between NASA DC-8 and NASA GRC, DFRC, and ARC.
- Sustained connectivity except under extreme bank/roll/heading profiles (e.g., greater than 35 degrees roll).

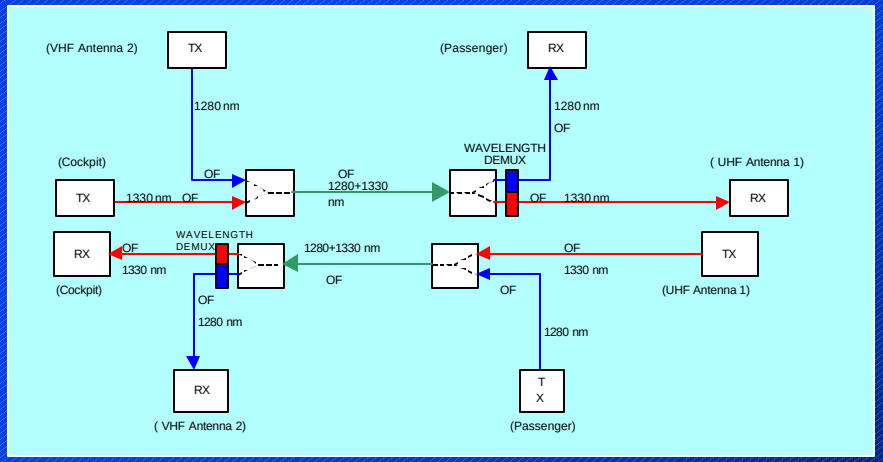
Conducted simultaneous applications:

- IP (web browsing/serving, email, telnet, FTP, Voice-over-IP)
- ATN (Controller Pilot Data Link Comm)
- Remote Buffered Network Bus (prioritization and security features)
- Live video and DC-8 Digital Air Data System transmission

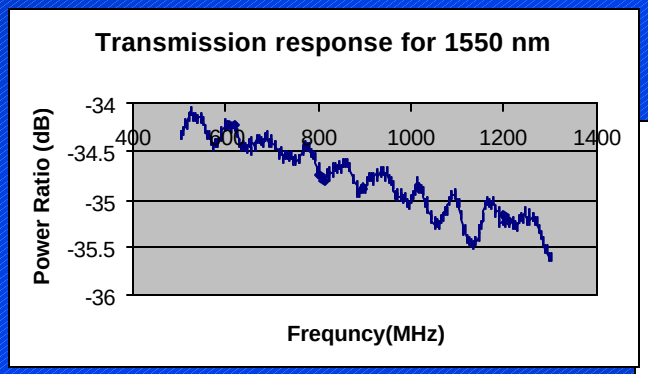
Fiber-optic Broadband Signal Distribution

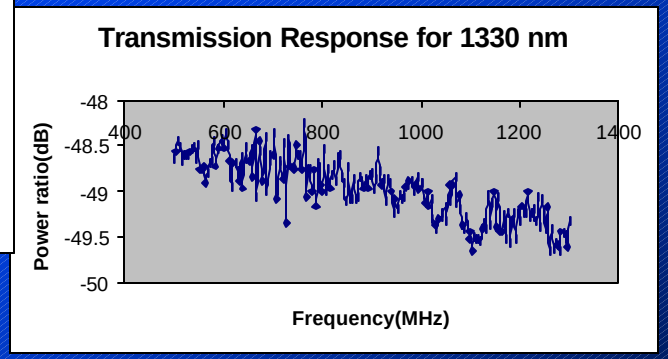
Research into the design and implementation of a fiber-optic network architecture and technologies capable of transport high bandwidth RF, microwave and millimeter wave signals for communications and other avionics applications on board an aircraft

- Provide signal distribution of high bandwidth data signals
- Allow multiplexing of highly diverse signals types
- Enable low electromagnetic interference, lower weight



Fiber-optic network testbed under development





Summary

NASA Glenn Aeronautical Communications R&D Programs:

- Advanced Communications for Air Traffic Management (AC/ATM): Satellite Communications, CNS for Distributed Air-Ground TM
- Weather Information Communications (WINCOMM): Air Transport to General Aviation, Nat'l & Worldwide Datalink Communications
- Small Aircraft Transportation System (SATS): Airborne Internet
- Virtual Airspace Modeling and Simulation (VAMS): CNS Systems

Aeronautical Communications Technology Development:

- Ground-based datalink technologies for GA
- Narrowband satellite communications technologies for GA
- Ground-based datalink technologies for Air Transport
- Narrowband and broadband satellite communications technologies for Air Transport
- Supporting technology developments – antennas, modulation/coding,, signal distribution, network technologies and protocols.